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Jc688 U.S. PTO 11/08/99

Jc598 U.S. PTO 09/436387 11/08/99

REISSUE PATENT APPLICATION TRANSMITTAL

Address to:

Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

Attorney Docket No.	P-4419.001
First Named Inventor	Rolin F. Barrett
Original Patent Number	5,788,178
Original Patent Issue Date (Month/Day/Year)	August 4, 1998
Express Mail Label No.	

APPLICATION FOR REISSUE OF: (check applicable box) [X] Utility Patent [ ] Design Patent [ ] Plant Patent

APPLICATION ELEMENTS

1. [X] * Fee Transmittal Form *(PTO/SB/56)* *(Submit an original, and a duplicate for fee processing)*
2. [X] Specification and Claims (*amended, if appropriate*)
3. [X] Drawing(s) *(proposed amendments, if appropriate)*
4. [X] Reissue Oath / Declaration (original or copy) *(37 C.F.R. § 1.175)(PTO/SB/51 or 52)*
5. Original U.S. Patent
   [X] Offer to Surrender Original Patent *(37 C.F.R. § 1.178) (PTO/SB/53 or PTO/SB/54)*
   or
   [ ] Ribboned Original Patent Grant
   [ ] Affidavit / Declaration of Loss *(PTO/SB/55)*
6. Original U.S. Patent currently assigned?
   [ ] Yes [X] No
   (If Yes, check applicable box(es))
   [ ] Written Consent of all Assignees *(PTO/SB/53 or 54)*
   [ ] 37 C.F.R. § 3.73(b) Statement [ ] Power of Attorney

ACCOMPANYING APPLICATION PARTS

7. [ ] Foreign Priority Claim *(35 U.S.C. 119)* *(if applicable)*
8. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
9. [ ] English Translation of Reissue Oath/Declaration *(if applicable)*
10. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [X] Statement filed in prior application, Status still proper and desired
11. [X] Preliminary Amendment
12. [X] Return Receipt Postcard *(MPEP 503)* *(Should be specifically itemized)*
13. [ ] Other: ....

NOTE FOR ITEMS 1 & 10: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

14. CORRESPONDENCE ADDRESS

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REISSUE APPLICATION FEE TRANSMITTAL FORM

Docket Number (Optional)
4419.001

Claims as Filed - Part 1

Claims in Patent	For	Number Filed in Reissue Application	(3) Number Extra	Small Entity Rate	Small Entity Fee		Other than a Small Entity Rate	Other than a Small Entity Fee
(A) 16	Total Claims (37 CFR 1.16(j))	(B) 16	**** =	x $____ =		or	x $____ =	
(C) 2	Independent Claims (37 CFR 1.16(i))	(D) 2	* =	x $____ =			x $____ =	
				Basic Fee (37 CFR 1.16(h))	$380			$
				Total Filing Fee	$380	OR		$

Claims as Amended - Part 2

	(1) Claims Remaining After Amendment		(2) Highest Number Previously Paid For	(3) Extra Claims Present	Small Entity Rate	Small Entity Fee		Other than a Small Entity Rate	Other than a Small Entity Fee
Total Claims (37 CFR 1.16(j))	*** 32	MINUS	** 20	* = 12	x $ 9 =	108	or	x $____ =	
Independent Claims (37 CFR 1 16(i))	*** 7	MINUS	***** 3	= 4	x $39 =	156		x $____ =	
				Total Additional Fee		$264	OR		$

* If the entry in (D) is less than the entry in (C), Write "0" in column 3.
** If the "Highest Number of Total Claims Previously Paid For" is less than 20, Write "20" in this space.
*** After any cancelation of claims
**** If "A" is greater than 20, use (B -A); if "A" is 20 or less, use (B - 20).
***** "Highest Number of Independent Claims Previously Paid For" or Number of Independent Claims in Patent (C).

☐ Please charge Deposit Account No. ____________ in the amount of ____________. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any additional fees under 37 CFR 1.16 or 1.17 which may be required, or credit any overpayment to Deposit Account No. 18-1167. A duplicate copy of this sheet is enclosed.

☒ A check in the amount of $ 644.00 to cover the filing / additional fee is enclosed.

11/4/99
Date

[signature]
Signature of Applicant, Attorney or Agent of Record

Larry L. Coats
Typed or printed name

REISSUE APPLICATION BY THE INVENTOR, OFFER TO SURRENDER PATENT	Docket Number (Optional) 4419.001

This is part of the application for a reissue patent based on the original patent identified below.

Name of Patentee(s) Rolin F. Barrett, Jr.

Patent Number 5,788,178 | Date Patent Issued August 4, 1998

Title of Invention Guided Bullet

I am the inventor of the original patent.

I offer to surrender the original patent.

1. ☐ Filed herein is a certificate under 37 CFR 3.73(b).

2. ☒ Ownership of the patent is in the inventor(s), and no assignment of the patent has been made.

One of boxes 1 or 2 above must be checked.

The written consent of all assignees owning an undivided interest in the original patent is included in this application for reissue.

Signature	Date
Rolin F. Barrett, Jr.	11-4-98

Typed or printed name
Rolin F. Barrett, Jr.

The assignee owning an undivided interest in said original patent is N/A, and the assignee consents to the accompanying application for reissue.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application, any patent issued thereon, or any patent to which this declaration is directed.

Name of assignee

Signature of person signing for assignee	Date

Typed or printed name and title of person signing for assignee

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Reissue Application of	:	
Rolin F. Barrett	:	
Patent No.: 5,788,178	:	Christopher K. Montgomery Examiner Group Art Unit 2201
Issue Date: 04 August 1998	:	
For: **GUIDED BULLET**	:	
Attorney Docket No. P-4419-001	:	

Cary, North Carolina
November 4, 1999

PRELIMINARY AMENDMENT

Assistant Commissioner of Patents
Box Reissue
Washington, D.C. 20231

Sir:

This preliminary amendment accompanies an application to reissue the above-style patent.

IN THE CLAIMS

Please insert new claims 17-32 as follows:

17. A bullet of the type fired from a pistol or rifle that includes an on-board laser guidance system for altering and directing the flight of the bullet along a trajectory, to a target that is identified by a laser beam projecting onto the target, the bullet comprising:

- at least one laser beam detector mounted on the bullet for detecting the reflection of the laser beam off the target, and producing signals that generally indicate whether the laser beam detector is oriented to detect the reflection of the laser beam off the target,
- a logic circuit mounted on the bullet and coupled to the laser beam detector for receiving the signals from the laser beam detector and producing corrective signals that are indicative of the degree of bullet reorientation required to position the laser beam detector such that it detects a reflection of the laser beam off the target,
- a steering controller mounted on the bullet and coupled to the logic circuit for receiving the corrective signals and utilizing the corrective signals to alter the flight path of the bullet so as to position the laser detector such that it detects the reflection of the laser beam off the target, and
- a power supply contained within the bullet for providing power to the laser beam detector, logic circuit and the steering controller.

18. The bullet of claim 17 wherein the bullet is provided with a plurality of symmetrically disposed laser beam detectors, and wherein the steering controller during the flight of the bullet continues to reorient the bullet such that the signals produced by the plurality of laser beam detectors are generally equal.

19. The bullet of claim 18 wherein the bullet includes three laser beam detectors.

20. The bullet of claim 17 wherein the bullet includes a longitudinal axis and a plurality of laser beam detectors symmetrically disposed about the longitudinal axis, and wherein each laser beam detector produces a signal that is directed to the logic circuit and wherein the steering controller acts to reorient the bullet such that each of the plurality of laser beam detectors detect the reflection of the laser beam off the target.

21. The bullet of claim 17 wherein the steering controller acts to reorient the bullet such that the bullet will strike the target.

22. The bullet of claim 20 wherein the plurality of laser beam detectors includes three separate laser beam detectors disposed in a plane that lies generally perpendicular to the longitudinal axis of the bullet and wherein the

steering controller acts to reorient the bullet such that each of the three laser beam detectors detect the reflection of the laser beam off the target.

23. The bullet of claim 20 including one or more control surfaces, and wherein the steering controller is operative to actuate the control surface in order to alter the flight path of the bullet.

24. A bullet adapted to be fired from a pistol or rifle and which includes an onboard laser guided system for altering and directing the flight of the bullet along a trajectory to a target that is identified by a laser beam projecting onto the target, the bullet comprising:

a. an elongated housing having a longitudinal axis;

b. at least three laser beam detectors mounted on the bullet for detecting the reflection of laser beam off the target and producing signals that generally indicate whether each respective laser beam detector is oriented to detect the reflection of the laser beam of the target;

c. the at least three laser beam detectors being generally transversely aligned and generally uniformly spaced about the longitudinal axis of the housing;

d. a logic circuit mounted on the bullet and coupled to the laser beam detectors for receiving the signals from the laser beam

detectors and producing corrective signals that are indicative of the degree of bullet reorientation required to position the laser beam detectors such that they detect a reflection of the laser beam off the target;

e. a steering controller mounted on the bullet and coupled to the logic circuit for receiving the corrective signals and utilizing the corrective signals to alter the flight path of the bullet so as to position the laser beam detectors such that they detect the reflection of the laser beam off the target; and

f. a power supply contained within the bullet for providing power to the laser beam detectors, logic circuit and the steering controller.

25. The bullet of claim 24 wherein during the flight of the bullet, the steering controller acts to reorient the bullet such that the signals produced by the laser beam detectors are generally equal.

26. A method of guiding a bullet fired from a pistol or rifle comprising:

a. identifying a target by directing a laser beam onto the target and aiming the bullet at the target;

b. firing the bullet at the target;

c. during the flight of the bullet, utilizing at least one laser beam detector for detecting the reflection of the laser beam of the target;

d. generating electrical signals that generally indicate whether the at least one laser beam detector is oriented to detect the reflection of the laser beam off the target;

e. producing corrective signals that are indicative of the degree of bullet reorientation required to position the at least one laser beam detector such that it detects a reflection of the laser beam of the target;

f. directing the corrective signals to a steering controller disposed on the bullet and utilizing the corrective signals to actuate the steering controller so as to alter the path of the bullet in such a fashion that the at least one laser detector detects the reflection of the laser beam off the target; and

g. supplying on board power to the bullet for powering the at least one laser detector and the steering controller.

27. The method of claim 26 wherein the bullet includes a housing having a longitudinal axis and wherein there is provided at least three laser beam detectors mounted on the housing and generally transversely aligned and uniformly spaced around the longitudinal axis.

28. The method of claim 27 wherein the steering controller continues to reorientate the bullet such that all three laser beam detectors detect the reflection of the laser beam off the target.

29. The method of claim 28 wherein the steering controller continues to reorient the bullet such that the signals generated by the laser beam detectors are equal.

30. A method of generating signals on board a pistol or rifle bullet that indicates the general orientation of the bullet relative to a target comprising:

sensing the reflection of light reflected off the target by at least two light detectors carried on the bullet;

each light detector generating an electrical signal that is a function of the intensity of the reflected light sensed by that light detector; and

comparing, on board the bullet, the electrical signals of each light detector and producing an output signal that is a function of the bullet reorientation required to cause the generated electrical signals to approximate or equal each other.

31. The method of claim 30 wherein at least three separate and distinct electrical signals are generated on board the bullet and wherein each

electrical signal is compared with the other two electrical signals to produce a single output signal.

32. A pistol or rifle bullet having an onboard system for determining the orientation of the bullet with respect to a target comprising:

at least two light detectors carried on board the bullet for sensing light reflected off the target and each light detector generating an electrical signal that is a function of the intensity of the reflected light sensed; and

an onboard logic circuit for comparing the electrical signals of each light detector and producing an output signal that is a function of the reorientation of the light detectors required to cause the generated electrical signals of the light detectors to approach or equal each other.

REMARKS

This preliminary amendment accompanies an application to reissue U.S. Patent 5,788,178, which originally issued 04 August 1998. New claims 17-32 have been added which eliminate the means plus function language of the original apparatus claims. All claims 1-32 are now pending as of the date of this amendment.

Support for the new claims as presented can be found in the patent in Columns 5-8. Specifically, in claim 17, the "at least one laser beam detector" corresponds to the laser sensor array 20; the logic circuit is labeled 28; the steering controller in the particular embodiment illustrated corresponds to the piezo-electric flaps 30, however, it should be appreciated that the new claims presented herewith encompass other steering mechanisms besides the design illustrated in the specification; and the power supply is labeled 35. Claims 18 and 19 include more of the sensors in array 20. Claims 20 and 22 are described at Col. 6, lines 2-5. The control surfaces are the piezo-electric surfaces 30.

Claim 24's housing is seen in Fig. 2; all other elements previously described. The elements of claim 23 and 25-32 are either described herein or readily apparent from the specification.

Applicant further requests a transfer of the drawings from the original patent file to the reissue application. MPEP §1413.

Applicant respectfully requests claim examination at the Examiner's earliest convenience.

Respectfully submitted,

COATS & BENNETT, PLLC

By: [signature]
Larry L. Coats
Registration No. 25,620

Telephone: (919) 854-1844

CERTIFICATE OF MAILING

I HEREBY CERTIFY THAT THIS DOCUMENT IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE AS FIRST CLASS MAIL, POSTAGE PREPAID, IN AN ENVELOPE ADDRESSED TO: **ASSISTANT COMMISSIONER OF PATENTS, BOX REISSUE, WASHINGTON, D.C. 20231.**

SIGNATURE [signature]

DATE 11/4/99

GUIDED BULLET

This application is a continuation-in-part of application Ser. No. 08/660.700. filed Jun. 5. 1996. now abandoned.

SPECIFICATION

This application claims the benefit of U.S. Provisional Application No. 60/002.608 filed Jun. 8. 1995 by Rolin F. Barrett. Jr. for Guided Bullet.

BACKGROUND OF INVENTION

1. Field of Invention

This invention relates generally to guided projectiles and. more particularly. to a self-contained laser guided system capable of maneuvering an in-flight. small caliber bullet to a designated target.

With the end of the Cold War. the nature of the threat to American interests has changed from a clash of super powers to multiple. low intensity conflicts fueled by regional and intranational differences. The demands of avoiding non-combatant causalities. placed on an army engaged in low intensity conflict. has led to the development of precision munitions and/or so-called SMART munitions.

Many guidance systems have been proposed for use with missiles and projectiles. In the case of projectiles. the majority of such guidance systems are useful only for larger calibers and are not compatible with precision rifle fire at the level of performance expected of a sniper.

Sniper rifle performance has been expressed as the smallest angle from the sniper rifle muzzle into which all of the shots from a rifle can be fired. The performance of a sniper rifle has usually been expressed in minutes of angle.

Some of the current precision rifles have placed all of their shots into a circle subtending a quarter of a minute of angle if the human operator was capable of his part in this performance.

Despite the high level of performance offered by current precision sniper rifles. the full potential of these rifles is rarely utilized due to the human limitations of the sniper operator. Under normal conditions a typical sniper operator can achieve one minute of angle. Under adverse conditions the typical sniper operator may only achieve two to three minutes of angle. Thus. efforts to improve sniper equipment using conventional unguided bullets are beginning to reach a point of diminishing returns.

The present invention has been developed to provide a laser guided bullet adapted for long range. precision fire by sniper trained personnel. The guided projectile of the present invention includes a self-contained guidance mechanism that is capable of guiding an in-flight bullet along an optimum trajectory to a laser designated target.

2. Description of Related Art

U.S. Pat. No. 46.490 to Thomas G. Orwig discloses a small caliber projectile that includes a telescopic stem provided with wings wherein the stem elongates by its own inertia after the projectile leaves the muzzle of a barrel of the firing weapon increasing the range. velocity. and force. and also the certainty of striking the object fired at.

U.S. Pat. No. 1.277.942 to John M. Kaylor discloses a projectile with sustaining wings and a stabilizing fin tending the hold the projectile to a direct forward course during its flight and prevent lateral canting or turning thereof.

U.S. Pat. No. 412.670 to George B. Ross discloses a projectile having two or more turbine wings which are

deployed at the moment the projectile leaves the gun for the purpose of causing its rotation during flight thereby increasing its range and accuracy.

U.S. Pat. No. 3.977.629 to Jean Tubeuf discloses a projectile guidance system which employs entry and exit ports for an ambient fluid medium with fluidic circuits interconnecting various of the entry and exit ports so that asymmetry of the flow through the ports induces the desired yawing torque on the projectile.

U.S. Pat. No. 3.860.199 to Brian B. Dunne discloses a laser-guided projectile system for guiding a spinning in-flight projectile by determining the deviation of the projectile from an optimum trajectory along which the projectile would impact a target. and transmitting a predetermined signal to the projectile from a remote source to subject the projectile to a correctional impulse of sufficient magnitude to alter the course of the projectile toward the intended target. However. this system is not self-contained on board the projectile nor does it utilize steering control surfaces in the manner of the present invention.

U.S. Pat. No. 4.537.371 to William S. Lawhorn. et al. discloses a small caliber guided projectile using flow control means for the control of exhaust through opposing nozzles to provide lateral position corrections to the projectile.

U.S. Pat. No. 1.243.542 to William R. Moore discloses a projectile having wings which will open when the projectile leaves a gun to prevent tumbling of projectile.

U.S. Pat. No. 4.431.150 to Edwin H. Epperson. Jr. discloses a gyroscopically steerable bullet having the capability for mid-course trajectory shaping thereby improving accuracy.

U.S. Pat. No. 4.711.152 to Chris M. Fortunko discloses an apparatus for transmitting data from the exterior of a gun tube to a projectile positioned within the gun tube utilizing at least two electromagnetic-acoustic transduction devices imparting updated target or trajectory information to the projectile.

U.S. Pat. No. 3.282.540 to Henry S. Lipinski discloses a gun launched guided projectile wherein the forward inner cone surface of a shaped charge includes a curved reflecting surface against which reflected light rays from the target entering the projectile nose are reflected onto a forward reflecting surface and thence to a target sensing device for determining the effectiveness of the projectile trajectory.

Finally. U.S. Pat. No. 4.893.815 to Larry Rowan is considered of general interest in that it discloses a multiple task user based weapons system capable of neutralizing a variety of designated target types within a real time interval well below conventional systems faced with equivalent tasks.

SUMMARY OF INVENTION

After much research and study into the above mentioned problems. the present invention has been developed to provide a small caliber. laser guided projectile system for guiding an in-flight bullet along an optimum projectory to impact a laser designated target.

The laser guided bullet of the present invention includes a self-contained guidance system having an array of symmetrically disposed. laser sensors capable of detecting a laser light beam reflected off of a remote target.

Sensory impulses from the laser sensors are transmitted to the on-board semiconductor logic circuit which determines the deviation of the bullet from an optimum trajectory. Thereafter. the on-board navigational electronics provide

voltage to a piezo electric steering mechanism to alter the path of the bullet along its trajectory.

The electrical power required to produce the functions within the guidance system is supplied by an on-board miniature battery.

In view of the above. it is an object of the present invention to provide a sufficiently small and lightweight laser guided bullet so that a reasonably small caliber, such as a standard 0.50 caliber M-2 cartridge can be accurately guided to a remote target by use of a laser target signature

Another object of the present invention is to provide a guided bullet that is launched by expanding gases in the manner employed by conventional bullets and is steered in flight by a self-contained guidance system that is capable of greater accuracy and precision than conventional bullets at all ranges.

Another object of the present invention is to provide a laser guided bullet that is steered in flight by a self-contained guidance system capable of determining the deviation of the bullet from an optimum trajectory along which the same will impact a target and of generating a correctional impulse to piezo electric actuated control surfaces to alter the course of the bullet toward the optimum trajectory.

Another object of the present invention is to provide a laser guided bullet capable of satisfactory performance under normal operating conditions thereby compensating for unknown factors and human operator limitations. Such unknown factors include but are not limited to wind, barometric pressure. humidity. effective impact with rain. sleet. snow. hail. or airborne soil particles. and movement of the target. Such human operator limitations include but are not limited to eyesight resolution. neuromuscular coordination. heartbeat. and respiration induced motion.

Another object of the present invention is to provide a laser guided bullet which may be produced by existing micro-manufacturing methods in an economically viable package.

Other objects and advantages of the present invention will become apparent and obvious from a study of the following description and the accompanying drawings which are merely illustrative of such invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is an exploded plan view of a standard 12.7×99 mm N.A.T.O. (0.50 caliber M-2) cartridge utilized in conjunction with the present invention:

FIG. 2 is a side elevational view of the guided bullet of the present invention;

FIG. 3 is a front elevational view of the guided bullet of the present invention showing the symmetrical arrangement of the laser sensor array;

FIG. 4 is a schematic view of the guided bullet containing a guidance system in accordance with the present invention and the components thereof;

FIG. 5 is a block diagram illustrating the logic circuit of the present invention and the integrated components thereof;

FIG. 6 is a graphic depiction of the force necessary to correct for the force of the wind versus the distance traveled by the guided bullet;

FIG. 7 is a graphic depiction of the energy necessary to correct for the force of the wind versus the distance traveled by the guided bullet;

FIG. 8 is a graphic depiction of the power necessary to correct for the force of the wind versus the distance traveled by the guided bullet;

FIG. **9** is a graphic depiction of the vertical sensor angle necessary to correct for the force of the wind versus the distance traveled by the guided bullet; and

FIG. **10** is a graphic depiction of the horizontal sensor angle necessary to correct for the force of the wind versus the distance traveled by the guided bullet;

FIG. **11A** is a partial longitudinal section view of the guided bullet showing a deployable flap in the absence of a control voltage being applied thereto;

FIG. **11B** is a partial longitudinal section view of the deployable flap of FIG. **11A** shown with a control voltage being applied thereto;

FIG. **12** is a side elevational view of an alternative embodiment of the guided bullet of the present invention;

FIG. **13** is a cross sectional view of the forward sealing/alignment ring of the alternative embodiment of the guided bullet depicted in FIG. **12**; and

FIG. **14** is a cross sectional view of the aft alignment ring of the alternative embodiment of the guided bullet depicted in FIG. **12**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Before describing the guided bullet **10** of the present invention in detail, it may be beneficial to review the structure and function of precision rifles wherein the guided bullet **10** of the present invention is to be utilized.

By definition all rifles, precision or otherwise, have rifled barrels, that is, their barrels are tubes containing spiral grooves etched into the inner barrel wall. When a conventional unguided bullet has been fired from a rifle barrel, the surfaces of the grooves therein grip the bullet and impart a spin to the same. Spinning the conventional, unguided bullet provides a gyroscopic stability to the in-flight projectile.

In contrast, the guided bullet **10** of the present invention is designed to be fired from a non-rifled, smooth bored gun barrel. Imparting a spin to the guided bullet **10** of the present invention would not only be unnecessary, but it would also be detrimental to the performance of the same.

The gyroscopic stability imparted to a conventional, unguided bullet fired from a conventional rifled gun barrel creates an additional resistance to be overcome by the steering control mechanism. Thus, imparting a spin to the guided bullet **10** would require the logic circuit **28** included in the on-board navigational electronics to compensate for a phase displacement in the steering commands sent to the control surfaces as described hereinafter. Because the guided bullet **10** must incline its longitudinal axis relative to its trajectory to achieve steering, gyroscopic stability is undesirable.

As precision rifles used by sniper trained personnel have evolved, certain standards for precision and accuracy have emerged. The sniper rifle has a ballistic advantage over the normal infantry weapon do to its ability to perform reliably at longer ranges. The ballistic advantage of the sniper rifle occurs when it is capable of placing all of its shots into an area which, at the distance of the area from the rifle, subtends two to three minutes of angle.

Most contemporary sniping authorities place the minimum standard of performance for a sniper rifle at one minute of angle. Sniper rifles entering service with the United States Army are required to place shots in one-half of a minute of angle.

Even with a high level of performance, most sniper rifles have an effective range of not more than 1,000 meters. When

the sniper's mission necessitates that the shot be fired from greater than 800 to 1.000 meters. a heavy sniper rifle will likely be used.

The standard cartridge used in a heavy sniper rifle by the United States Armed Forces and N.A.T.O. Forces is the 12.7×99 millimeter N.A.T.O. (0.50 caliber M-2) cartridge as shown in FIG. 1. indicated generally at **15** and labeled PRIOR ART.

The 0.50 caliber cartridge **15** includes a generally cone-shaped projectile or bullet **16** which is secured about its mid-section within a cylindrical case **17** containing a gun powder charge (not shown).

Thus. the guided bullet **10** of the present invention is designed to be propelled by a standard 0.50 caliber M-2 cartridge (12.7×99 mm) presently in use by the United States Armed Forces. The 12.7×99 mm N.A.T.O. (0.50 caliber M-2) cartridge is the largest cartridge and fires the largest bullet currently in small arms standard use.

Since such conventional. unguided bullet cartridges are well-known to those skilled in the art. further detailed discussion of the same is not deemed necessary.

Under normal operating conditions. the ballistics of such small caliber projectiles are well known. However. due to random processes and unknown factors involving small differences and effects of powder load. projectile shape and mass. frictional forces as the projectile leaves the gun barrel. fluctuations in wind and air density. barometric pressure. humidity. the effect of impact with rain. sleet. snow. hail. or other airborne soil particles. a small caliber projectile may deviate from an optimum projectory along which the same would impact a target.

Thus. there is a need for a self-contained guidance system for guiding an in-flight. small caliber projectile toward an optimum trajectory along which the bullet would impact a target.

In order to simplify the description of the guided bullet **10** of the present invention. it may be beneficial to briefly review the function of a laser beam in designating a target in this context.

The light energy from a laser can be concentrated into a very narrow beam. The angle subtended by the laser beam at the ranges of interest for the present invention is dependent upon the quality of the optics in the laser apparatus. but also upon fluctuations in the density in the atmosphere. that is. refractive or bending effects. and to energy loss due to interactions from scattering processes with small density fluctuations or particulate matter such as dust or water droplets as the scattering centers. The angular width of the laser beam can be quite small.

Since the laser beam intercepts air density fluctuation or concentrations of particulate matter suspended within the atmosphere. a certain fraction of the beam power is scattered out of the beam and lost. However. the scattered intensity is in the generally forward direction of propagation of the beam.

When a laser beam is placed on a target. the beam is partially reflected in many different directions. Initially. the laser beam would be coherent and unseen by the laser sensor array. indicated generally at **20**. unless the laser beam were to be pointed directly at the laser sensor array **20** as shown in FIG. 2. Thus. the laser sensor array **20** could only detect that part of the laser beam that would be reflected by the target toward the guided bullet **10**.

The laser sensor array **20** of the present invention utilizes a plurality of individual laser sensors **25** in order to detect a

laser illuminated target position that does not lie on the longitudinal axis A of the guided bullet **10**. The laser array **20** is comprised of individual laser sensors **22** which are arranged symmetrically about a longitudinal axis A of the guided bullet **10** as shown in FIG. 3.

In the preferred embodiment three sensors **22***a*, **22***b*, and **22***c* are positioned symmetrically about the longitudinal axis A of the guided bullet **10** to provide the simplest configuration for detecting the radiant energy of the laser beam.

As the guided bullet **10** moves in the general direction of the laser illuminated target, a sufficient fraction of the laser beam energy is intercepted and transmitted through each respective sensor lens **23** that is focused on the sensitive photo detector elements **24** contained within each sensor **22** as shown in FIG. **4**. The photo detector elements **24** maybe fabricated from a variety of currently available materials responsive to laser radiation and capable of converting the laser radiation into electrical signals.

Since such laser sensors are well known to those skilled in the art, further detailed discussion of the same is not deemed necessary.

The electrical signals generated by the photo detector elements **24** are received by a logic circuit **28** integrated into a dedicated semiconductor chip **29** installed within the guided bullet **10** as shown schematically in FIG. **5**.

The electrical signals are amplified by micro-circuit amplifiers **26** to produce the functions required by the guidance system as shown in FIG. **5**. The V in FIG. **5** represents the voltage signal generated by each respective photo detector element **24** corresponding to its laser sensor **22**. Thus, Va represents the voltage signal produced by laser sensor **22***a* in response to the laser radiation intercepted thereby, etc.

The semiconductor chip **29** is installed on a generally flat plate **27** positioned within bullet **10** in generally perpendicular relation to axis A as shown in FIG. **4**

Since such semiconductor circuits are in a practical state of development and well known to those skilled in the art, further detailed discussion of the same is not deemed necessary.

The guided bullet **10** utilizes steering control surfaces to rotate the longitudinal axis A of its body out of alignment with the present direction of bullet travel. Thus, the guidance system is capable of generating a correctional signal to the steering control surfaces in response to the sensory input received from the laser sensors **22** to translate the bullet **10** to the optimum trajectory to hit the target. Tail fin stabilization will be required to impart directional stability to the guided bullet **10** in virtually all distance ranges to prevent tumbling of the projectile once it is subjected to a corrective moment from the steering control surfaces.

When utilized for stabilization, a plurality of fixed fins **38** are equally spaced circumferentially around the rearward end of the bullet body **11** as shown in FIG. **12**. In the embodiment shown four identical fins **38** are incorporated to form a tetragonal arrangement.

The present invention utilizes deployable flaps **30** as steering control surfaces as shown in FIG. **4**. Such deployable flaps **30** are comparable to aircraft flight control surfaces known as spoilers which function to increase drag and to decrease lift.

As necessary, the deployable flaps **30** are extensible out from the body **11** of the guided bullet **10** to deflect the air stream to effect steering of the guided bullet **10**. When the deployable flaps **30** are not needed to translate the bullet **10**

toward the optimum trajectory. the flaps **30** are disposed flush with the outer surface **11***a* of the guided bullet body **11** as more clearly shown in FIG. **11**A.

In the preferred embodiment. the deployable flaps **30** are fabricated using either hard or soft piezo electric material. Such piezo electric materials are capable of extension along one axis and contraction along another when subjected to an electric field and may be constructed in either a unimorph or bimorph configuration as is well known to those skilled in the art. As can be seen in FIGS. **11**A and **11**B. each of the flaps **30** are manufactured in a layered configuration including an inner layer **30***a* comprising piezoelectric material permanently bonded to the underside of an outer layer **30***b* of a synthetic material such as KEVLAR or other suitable material capable of withstanding bore firing pressures and temperatures.

As shown in FIG. **11**A. flap **30** is configured to closely conform to and to be disposed within a recessed area as at **32** formed in the outer surface **11***a* of the guided bullet body **11**.

In the presence of an applied controlled voltage provided by an onboard power source. the piezoelectric layer **30***a* is extended in length along its longitudinal axis causing the outer layer **30***b* of KEVLAR to bend outwardly beyond the outer surface **11***a* of the bullet body **11** as shown in FIG. **11**B.

Since such piezo electric materials are well known to those skilled in the art. further detailed discussion of the same is not deemed necessary.

Thus. the piezo electric flaps **30** are extensible from the body **11** of the guided bullet **10** to deflect the air stream in order to correct the in-flight course of the bullet **10** along a desired trajectory. This is accomplished through the onboard logic circuit **28** which controls the flow of electrical current to the piezo electric flaps **30**.

Electrical power to operate the guided bullets sensors **22**. logic circuit **28** and piezo electric flaps **30** is provided by an onboard miniature battery **35** which provides sufficient duration of electrical power supply to support the functions of the guidance system.

In the preferred embodiment. a lithium-polymer battery provides the most suitable power source for the guided bullet **10**. Lithium-polymer batteries have an unusually thin cell thickness on the order of hundreds of micrometers

During the firing process. the miniature battery **35** is subjected to potentially damaging acceleration. Most conventional batteries are constructed starting with a metal cup. This metal cup is filled with the appropriate chemical composition. The combination of metal cup and appropriate chemical composition is sealed within a metal cap. The metal cap is electrically separated from the metal cup by an electrical insulating medium. If a battery of this type of construction is subjected to sufficiently large acceleration. the battery will fail structurally. If the battery fails structurally. the battery will almost certainly fail electrically.

Since a lithium-polymer battery is thinner than most batteries and layered. the lithium-polymer battery **35** can constructed to withstand the guided bullet **10** firing acceleration. This is mentioned because this invention is only possible in practice by the use of such a battery. Control voltages are applied to the piezoelectric flaps from the battery **35** through the integrated functions of logic circuit **28**. The battery **35**. flaps **30** and logic circuit **28** are electrically connected by conductors such as wires (not shown) sheathed in an insulating coating and embedded in plurality of channels **36** formed in the body **11** of the guided bullet.

The channels **36** are formed in the bullet body **11** by drilling. milling. or other known machine tool processes.

The insulated conductors are rigidly secured within channels **36** by epoxy or other suitable adhesive means to withstand bore firing pressures.

In an alternative embodiment the electrical conductors are comprised of an electroconductive paint mixed with an epoxy compound which fills channels **36** to electrically interconnect the components of the guidance system.

Since such electroconductors are well known to those skilled in the art, further detailed discussion of the same is not deemed necessary.

Turning now to FIG. **12**, there is shown therein an alternative embodiment of the guided bullet of the present invention indicated generally at **10'**. In this embodiment a plurality of deployable flaps **30'** are symmetrically disposed about the forward end **11***b* of the projectile to translate the guided bullet **10'** toward the optimum trajectory in substantially the same manner as described hereinabove.

In this embodiment the deployable flaps **30'** are constructed of the same piezoelectric materials and the control voltages are applied thereto in essentially the same manner as previously described herein.

Although the aerodynamic effects of the forward mounted steering flaps **30'** on the in-flight projectile and the correctional momentum imparted to the in-flight bullet may vary considerably from the rearward flaps **30** such variable parameters are considered to be within the scope of the present invention.

A significant difference in the embodiment shown in FIG. **12** is the inclusion of a plurality of laser sensor patches, which are equally spaced circumferentially about the forward end of the bullet **10'**. The sensor patches **25** are comprised of a fiber optic material which optically connects the laser sensors **22** that are disposed internally of the bullet body **11'**.

In this arrangement a plurality of laser sensors **22** may be disposed in axial alignment along the longitudinal centerline of the projectile such that only their respective sensor patches **25** extend to the external surface of the bullet body **11** thereby permitting a reduction in outside diameter and caliber of the guided bullet **10'**.

Still referring to FIG. **12** the guided bullet **10'** is provided with a forward sealing/alignment ring **39** and a rearward alignment ring **40** which are disposed circumferentially around the body **11** of the projectile.

In the preferred embodiment both the forward sealing/alignment ring **39** and the rearward alignment ring **40** are circular in configuration as more clearly shown in FIGS. 13 and 14 respectively.

In the preferred embodiment both rings **39** and **40** are fabricated from a soft metal or plastic material and function to align the guided bullet **10'** in the bore of the firing rifle and to protect surfaces of the guided bullet body **11** and the bore of the weapon (not shown) from friction and damage during firing. In addition, the forward ring **39** functions to reduce leakage of combustion gases during firing while the rearward ring **40** includes a plurality of symmetrically spaced undercut areas **40***a* which permit the flow of combustion gases past the rearward ring **40** during firing.

In this alternative embodiment directional stability is provided by a plurality of fixed tail fins **38** which are equally spaced circumferentially around the rearward end of the bullet body **11**.

In the following description, consideration is given to how the guidance system of the guided bullet **10** is effected in practice. Initially, it is assumed that the guided bullet is

installed into a standard 0.50 caliber M-2 cartridge (12.7×99 mm) presently in use by the United States Armed Forces. More particularly, the diameter of the guided bullet **10** is 12.954 mm (0.510 inches) in diameter, the same diameter as the conventional, unguided bullet of this caliber.

In the preferred embodiment, the body **11***b* of the guided bullet is fabricated from copper or other suitable metal alloy.

The maximum acceptable overall length of the standard 0.50 caliber M-2 cartridge is 138.43 mm (5.45 inches), if it is desired for the cartridge to be used in auto-loading weapons such as semi-automatic precision sniper rifles. If the guided bullet **10**, as assembled in the standard 0.50 caliber M-2 cartridge, is to be used in a manually loaded weapon, the overall length may exceed 138.43 mm.

A weapon which is configured to fire the guided bullet **10** will have no rifling to affect the seating depth of the guided bullet **10** as loaded in the standard 0.50 caliber M-2 cartridge. Since the guided bullet **10** will be used in smooth bored, manually loaded precision sniper weapons the overall cartridge length can exceed the maximum acceptable cartridge length for the standard 0.50 caliber M-2 cartridge.

A conventional, unguided standard 0.50 caliber M-2 bullet will travel 3,000 meters in approximately 16 seconds. Under optimum conditions the laser beam will be directed at the target at an appropriate angle so that at or near the mid-point of the bullet flight any deviation from the optimum trajectory can be corrected. More particularly, the guided bullet **10** will acquire the target signature and begin navigating toward the target when it is less than approximately 1,100 meters from that target. Since the guided bullet **10** will most likely use electrical power only in the last 1,100 meters or less of travel, significant power consumption will not occur for more than three seconds.

A simplified way of considering the trajectory correction required is contained in the following analysis.

It is first assumed that E is the energy necessary for course correction. y is the lateral distance movement necessary for course correction. Fy is the lateral force on the guided bullet **10** necessary for course correction. This may be written as follows:

$$Fy=E/y$$

Fx is the force along the x-axis.

$$Fx=A\cdot p\cdot va^2\cdot(1-\cos(\theta))Cd$$

A=the cross sectional area for the bullet, Cd=coefficient of drag, p is obtained by a linear interpolation of air density data, p is the density of air in kilograms per cubic meter.

$p=120+(20-\text{temp})\cdot 0.045$

v=the velocity of the bullet at a given position of the bullet in travel

a=sample bullet specimen having a coefficient of drag equal to 0.2

θ=elevation angle of bullet

Fy is the force along the y-axis.

$$Fy=A\cdot p\cdot va^2\cdot(1-\sin(\theta))$$

tL is the typical minimum thickness of a single soft piezo electric strip in meters.

$$tL=1\cdot 10^{-4}$$

R is the radius of a single activated soft piezo electric strip. ΔL is the change in length of a single activated soft piezo

electric strip in meters.

$$\Delta L = \frac{R + tL/2}{2/R \quad L - L}$$

ϵ is the strain of a single activated soft piezo electric strip.

$$\epsilon = \Delta L / L$$

d31 is the piezo electric sensitivity in meters per Volt.

$$d31 - 275 \cdot 10^{-12}$$

V is the required voltage in Volts

$$V = \epsilon / d31\ tL$$

Appropriate logic or computational elements in the logic circuit **28** would select the optimum discrete voltage input to activate the piezo electric flaps **30** to effectuate the optimum trajectory correction as depicted in FIG. **5**, which would depend upon the following factors: the force necessary to correct for the wind on the guided bullet **10** versus the distance traveled by the bullet **10**, energy necessary to correct for the force of the wind on the bullet **10** versus the distance traveled by the bullet **10**, power necessary to correct the force of the wind on the bullet **10** above the muzzle versus the distance traveled by the bullet **10**, vertical angle known as the vertical field of view necessary for the bullet sensors **22** to acquire the laser target signature versus the distance traveled by the bullet **10**, horizontal angle known as the horizontal field of view necessary for the bullet sensors **22** to acquire the target signature versus the distance traveled by the bullet **10**, and the resultant angle known as the field of view necessary for the bullet sensors **22** to acquire the target signature versus the distance traveled by the bullet **10**.

The force necessary to correct for the force of the wind versus the distance traveled by the bullet **10** is shown in FIG. **6**. The energy necessary to correct for the force of the wind versus the distance traveled by the bullet **10** is shown in FIG. **7**. The power necessary to correct for the force of the wind versus the distance traveled by the bullet **10** is shown in FIG. **8**. The vertical sensor angle necessary to correct for the force of the wind versus the distance traveled by the bullet is shown in FIG. **9**. The horizontal sensor angle necessary to correct for the force of the wind versus the distance traveled by the bullet is shown in FIG. **10**.

It will be appreciated that the data presented in FIGS. **6–10** is based on a flight simulation of five distinct guided bullet specimens, namely a, b, c, d, and e.

Each respective bullet specimen has a different coefficient of drag value simulating a wide range of atmospheric conditions under which the guided bullet **10** will function.

More specifically, the respective coefficient of drag values are as follows:

Bullet Specimen	Coefficient of Drag Value
a	0.2
b	0.3
c	0.4
d	0.5
e	0.6

The flight simulation data contained in FIG **6–10** is provided to demonstrate that the forces required for course correction of the guided bullet **10** are within the functional capability of the hereinabove described ballistic and navigational technologies.

The computation of the trajectory of the guided bullet including deceleration due to air drag and calculation of the target position including elevation angle, and the determination of the optimum aiming direction is straightforward and reduced to practice and would require no further explanation to those reasonably skilled in this art.

From the above it can be seen that the laser-guided bullet of the present invention provides a method and system for guiding a small caliber projectile to an optimum trajectory along which the same would impact a hostile target. The guided bullet includes a self-contained guidance system capable of generating a correctional signal by means of a dedicated semiconductor logic circuit which actuates piezo electric steering surfaces on the bullet to translate the projectile toward the optimum trajectory.

The guided bullet of the present invention utilizes ballistic and navigational technologies which are in a practical state of development.

Because of the degree of precision that is required in the fabrication of the guided bullet and the small scale of the work, micro electromechanical manufacturing offers the potential for the lowest production cost of the present invention.

The terms "forward", "rearward", and so forth have been used herein merely for convenience to describe the present invention and its parts as oriented in the drawings. It is to be understood, however, that these terms are in no way limiting to the invention since such invention may obviously be disposed in different orientations when in use.

The present invention may, of course, be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of such invention. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

What is claimed is:

1. A bullet guidance system for guiding an in-flight bullet along an optimum trajectory along which said bullet would impact a laser-identified target, said system comprising:

laser beam detecting means contained within said bullet and being capable of receiving laser beam energy reflected from said target and converting said energy to electrical impulses;

logic circuit means contained within said bullet having means therein responsive to receipt of said impulses for determining the deviation of said bullet from said optimum trajectory and for generating corrective signals in response to said impulses;

steering control means having means therein responsive to said corrective signals in a manner to actuate said steering control means so as to deflect air flow about said bullet, said control means including at least deployable flap means being outwardly extensible from said bullet to deflect air flow about said bullet to impart a correctional momentum to translate said bullet to said optimum trajectory, said bullet being fired from a precision, smooth-bored weapon thereby not imparting axial spin to said bullet in the manner of a rifle; and

power supply means contained within said bullet being interconnectable to said logic circuit and said steering control means to provide sufficient electrical power to produce the functions required by said system.

2. The bullet guidance system of claim 1 wherein said detecting means includes a plurality of laser sensors being symmetrically disposed about a longitudinal axis of said bullet, said sensors being located in a plane perpendicular to the axis and being arranged to receive said laser beam

energy in an opposite direction to the direction in which said bullet is moving.

3. The bullet guidance system of claim 1 wherein said logic circuit means includes amplification means being integrated thereto for amplifying said impulses received from said detecting means.

4. The bullet guidance system of claim 1 wherein said logic circuit means includes amplification means and is contained in a semiconductor chip within said bullet.

5. The bullet guidance system of claim 4 wherein said semiconductor chip is installed on a flat plate means on a forward side thereof, said plate means being located in a plane perpendicular to said axis of said bullet.

6. The bullet guidance system of claim 1 wherein said deployable flap means are at least partially fabricated from piezo electric materials enabling said flap means to be expanded when subjected to said corrective signals.

7. The bullet guidance system of claim 1 wherein said power supply means is a miniature battery contained within said bullet.

8. The bullet guidance system of claim 7 wherein said battery is a lithium-polymer battery.

9. The bullet guidance system of claim 1 wherein said bullet is propelled by a powder cartridge.

10. The bullet guidance system of claim 9 wherein said cartridge is a 0.50 caliber cartridge.

11. A method of guiding an in-flight bullet along an optimum trajectory to a laser-identified target, said bullet including a self-contained guidance system including laser detection means capable of receiving laser beam energy and converting said energy to electrical impulses, logic circuit means responsive to receipt of said impulses for determining the deviation of said bullet from said optimum trajectory and for generating corrective signals in response to said electrical impulses for actuating steering control means in a manner to deflect air flow about said bullet thereby effecting a corrective momentum to translate said bullet to said optimum trajectory, said method comprising the steps of:

illuminating the target with a laser;

firing said bullet from a precision sniper rifle having a smooth internal bore at said target;

detecting laser beam energy reflected from said target using laser sensors;

converting said energy to electrical impulses;

determining the deviation of said bullet from said trajectory by analysis of said electrical impulses;

generating corrective signals in response to said electrical impulses; and

actuating said steering control means in response to said corrective signals in a manner to deflect air flow about said bullet to impart a correctional momentum to said bullet whereby said bullet is translated toward said optimum trajectory to impact said target.

12. The method of claim 11 wherein the step of detecting is carried out by a plurality of laser sensors symmetrically disposed about a longitudinal axis of said bullet.

13. The method of claim 11 wherein the step of converting is carried out by photo detector elements within said sensors.

14. The method of claim 11 wherein the step of determining is carried out by a semiconductor logic circuit.

15. The method of claim 11 wherein the step of determining is carried out by piezo electric materials integrally formed with said control means.

16. The method of claim 11 wherein the step of firing further includes propelling said bullet to said target by use of a powder charge.

* * * * *

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[11] **Patent Number: 5,788,178**

[45] **Date of Patent: Aug. 4, 1998**

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Attorney, Agent, or Firm—Mills Law Firm PLLC

[57] **ABSTRACT**

A small caliber laser-guided bullet having a self-contained guidance system is disclosed including on-board laser sensors and navigational circuits capable of detecting a laser target signature, determining the deviation of the bullet from an optimum projectory along which the bullet would impact a hostile target, and generating an electrical signal to piezo electric steering control surfaces to effect a change in the course of the bullet. The guided bullet utilizes a plurality of symmetrically-arranged laser sensor elements which are positioned about a longitudinal axis of the bullet. The laser sensor elements function to transmit optical radiation from the laser target beam to photo detector elements housed within the bullet. The electrical signals from the photo detector elements are then amplified and processed by semiconductor logic circuits to produce the functions required by the steering control surfaces to translate the bullet to the optimum trajectory. Electrical power for the guidance system is provided by a miniature lithium-polymer battery which is interconnected with the navigational circuits to produce the functions of the system. The guided bullet is fired from a precision, smooth bore weapon using a conventional expanding gas cartridge and is effective at ranges up to 3.000 meters and beyond.

16 Claims, 11 Drawing Sheets

United States Patent [19]

Barrett, Jr.

[54] **GUIDED BULLET**

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[21] Appl. No.: **888,425**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 660,700, Jun. 5, 1996, abandoned.

[60] Provisional application No. 60/002,608 Jun. 8, 1995.

[51] **Int. Cl.**^{6} **F41G 7/22**

[52] **U.S. Cl.** **244/3.11**; 244/3.21; 244/3.24; 102/501

[58] **Field of Search** 244/3.11, 3.13, 244/3.15, 3.16, 3.21, 3.24; 102/293, 501

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

REISSUE APPLICATION DECLARATION BY THE INVENTOR	Docket Number (Optional)

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is described and claimed in patent number 5,788,178, granted August 4, 1998, and for which a reissue patent is sought on the invention entitled Guided Bullet,

the specification of which

[X] is attached hereto.

[ ] was filed on ______________ as reissue application number ___ / __________
and was amended on ______________.
(If applicable)

I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.
I verily believe the original patent to be wholly or partly inoperative or invalid, for the reasons described below. (Check all boxes that apply.)

[ ] by reason of a defective specification or drawing.

[X] by reason of the patentee claiming more or less than he had the right to claim in the patent.

[ ] by reason of other errors.

At least one error upon which reissue is based is described as follows:

The independent appartus claim includes means plus function phrasing which applicant feels overlimits the scope of the invention.

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(REISSUE APPLICATION DECLARATION BY THE INVENTOR, page 2)

Docket Number (Optional)

All errors corrected in this reissue application arose without any deceptive intention on the part of the applicant. As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine and imprisonment, or both, under 18 U.S.C. 1001, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this declaration is directed.

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☐ Additional joint inventors are named on separately numbered sheets attached hereto.

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